Signal to Noise

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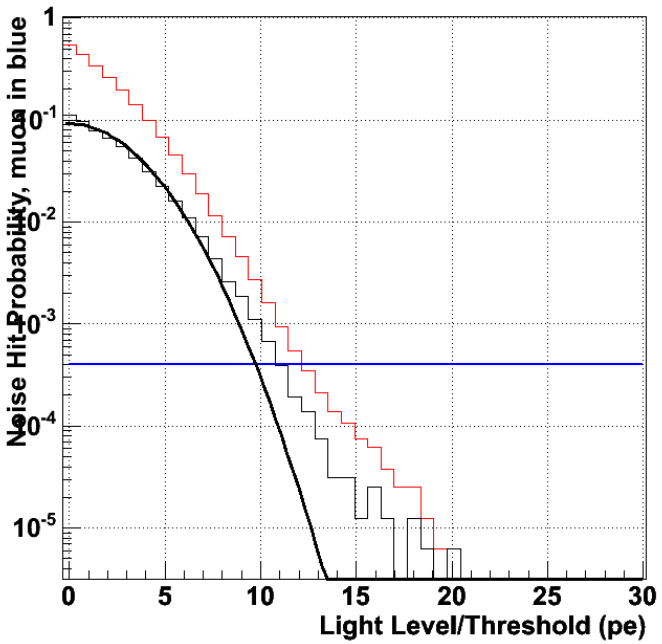
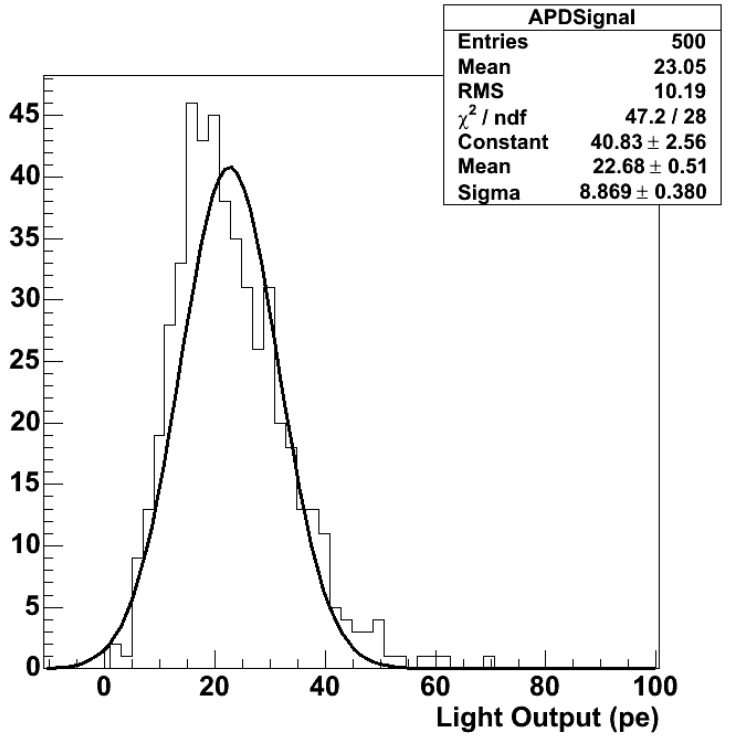
What does Signal to Noise Mean

- Not Much
- We have 2 distributions, the signal, and the pedestal.
- The pedestal has mean of 0 by definition, a width, and some additional component
- The signal also has a mean and a width.

Noise and Signal Distributions



- Noise has a mean of 0, and a width primarily due to Gaussian amplifier noise with a non-Gaussian tail

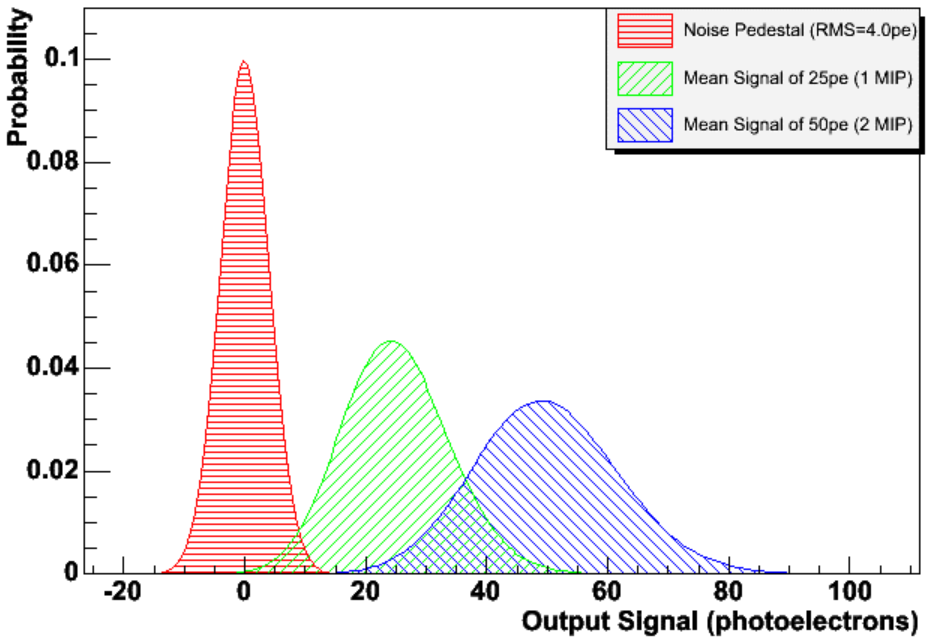


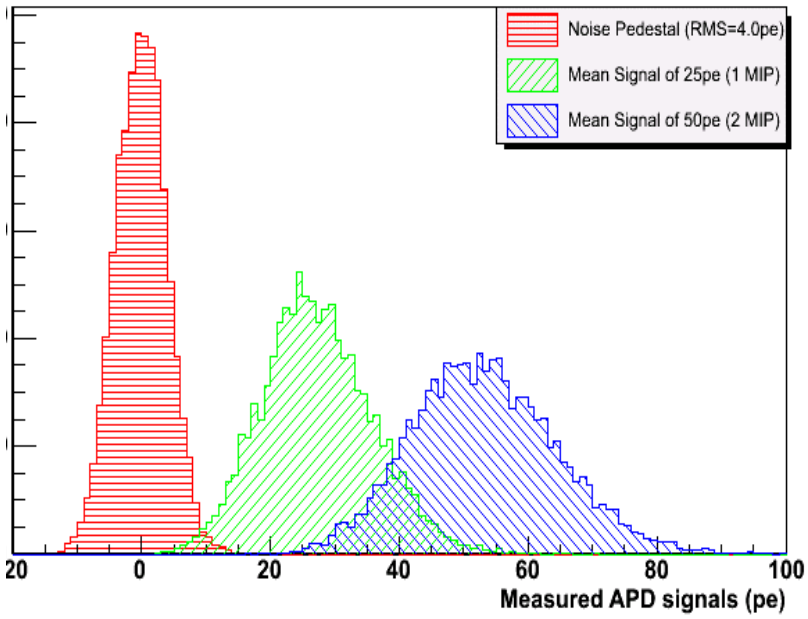
- Signal has some mean and a width primarily due to photostatistics, excess noise, and amplifier noise, it also has a tail

What Does Signal to noise mean Part II

- The Ratio tells you how many “sigma” your mean signal is separated from the noise.
- Bigger is better
- We can say what this number is, but it doesn’t tell you much.
- What you want to know is:
  - What is your perp-MIP efficiency?
  - How much noise do you have?

Simulated and measured pedestals





Best understanding of widths

- Signal width is due to a contribution from photostatistics, multiplication noise (excess noise) and amplifier noise.
- $\sim \sigma = \sqrt{N \cdot F + \sigma_A \cdot \sigma_A}$
  - N=signal mean
  - F=excess noise (2.5 at m=100)

So what S/N do we need?

- We need a threshold high enough that the DAQ can handle it, >~8 pe.
- We need a threshold that doesn't introduce significant noise in events, >9pe 1 hit/event
- We need to be able to set a threshold where the noise does not dominate. $<\sim 10^{-4}$
  - ~15pe
  - Lowering this introduces noise to data stream, could filter events, requires event selection to throw away noise
- We need sufficient efficiency to identify events
  - Pattern recognition pretty robust, need >~50%
    - >Npe (See simulations talk tomorrow.)

Conclusions

- We want lowest threshold to provide maximum efficiency
  - independent of signal
- For a simple “triggerless” DAQ the desired threshold would be 15pe
- This is unlikely to go down with quieter electronics.
  - Current electronics already reveal this noise
- Could reduce threshold more (10?pe) if we:
  - 1) Beef up DAQ
    - A) write lots of noise data to tape
    - B) introduce filtering trigger (ROI)
- But what signal? Tune in tomorrow (20-25)